

DEPARTMENT OF  
SCIENTIFIC AND INDUSTRIAL RESEARCH

Estimates of Resources  
Devoted to  
Scientific and Engineering  
Research and Development  
in British Manufacturing  
Industry, 1955



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## FOREWORD

THE Department of Scientific and Industrial Research (D.S.I.R.) reached the conclusion a few years ago that it was desirable, not only for the purpose of fulfilling its own responsibilities in allocating public moneys for the support of research but also from a wider national standpoint, that more should be known about the scale and distribution of expenditure on research and development. In particular, for the carrying out of its tasks of promoting research where the scale seemed inadequate, it was important to establish the orders of magnitude of existing expenditures by private businesses in manufacturing industry.

This report presents the results of the subsequent enquiry. The methods of estimation are set out in the report itself. The main task of organizing and conducting the initial investigation was entrusted to Mr. E. Rudd of the Department of Scientific and Industrial Research. The report however, as here printed, represents the considered views of the Economics Committee of the Council for Scientific and Industrial Research. I would like to express, on behalf of the Committee, our thanks to Mr. Rudd for the energy and ingenuity with which he carried out a most difficult task.

Three points should, I think, be stressed. First, while we believe that the figures here published give a reliable indication of the scale and distribution of research expenditure by manufacturing industry in total and that no better estimates could be produced in present circumstances of expenditure in the different main sectors of industry, we are aware that the estimates of research and development expenditure for individual industries more narrowly defined are inevitably subject to appreciable margins of error. The errors are likely to be greater, the greater the subdivision that is attempted.

Second, considerable caution is necessary in reaching conclusions as to the adequacy or inadequacy of research in any particular industry. The tasks of research are in different degrees divided between the operating industries, under which research expenditure is here analysed, and the industries which provide machinery, equipment and materials to the operating industries. Not all the research, for example, that goes into the improvement of the manufacture of automobiles is conducted within the automobile industry itself. In a number of cases the research expenditure by the operating industry considerably under-estimates the true volume of relevant research.

Third, research and development do not represent the only means by which science can be applied to industry. As the report itself stresses, the process of preliminary design and development of a prototype followed by the mass production of standardized units is not common to all industries. In many industries, of which shipbuilding, structural engineering and heavy electrical engineering provide a few examples, the task of design is in effect a normal part of production and expenditure upon it would not be included in the estimates of research and development here presented. Nor are the limits either of research or of development easily and clearly definable. We have been able to do no more than follow the normal practice of the industry immediately concerned. But in

interpreting the results of our enquiry, it is important to bear in mind that the application of science to industry is to be found not only in the research and development departments but also in departments concerned with design and the improvement of production, which in many—perhaps most—cases will escape inclusion in our estimates.

Despite all these qualifications the contrasts between the ratios of expenditure on research and development to turnover and net output in some of the science-based industries on the one hand and in some of the more traditional small-scale industries on the other hand clearly raise questions of great importance.

*October, 1958*

E. A. G. ROBINSON,  
*Chairman*

Economics Committee of the  
Council for Scientific and  
Industrial Research.

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# Estimates of Resources Devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955

## INTRODUCTION

AT a time when considerable attention is being paid to the problems involved in increasing the nation's scientific and technological resources it is natural to ask how existing resources are deployed. In 1957 the Advisory Council on Scientific Policy published estimates of the total national expenditure on research and development suggesting that the total expenditure in 1955-56 was of the order of £300 million. Of this total, it was estimated that some £185 million, or nearly 62 per cent was spent in private industry, about two-thirds of it on Government account. Nationalized industries (transport, coal-mining, gas, electricity, water supplies, the B.B.C.) were estimated to have spent £4 million.

The Advisory Council on Scientific Policy's estimate of private industry's expenditure was based on the preliminary results of an enquiry conducted by the Department of Scientific and Industrial Research (D.S.I.R.). This enquiry was designed to find out the cost of scientific research and technical development carried out by private manufacturing industries in Great Britain in 1955. It was not possible to distinguish the sources of funds allocated to this research and development. The value of Government research and development contracts with private industry was estimated independently by the Advisory Council on Scientific Policy, and is included in the Council's estimates of national expenditure on research and development in Great Britain, 1955-56, reproduced in Table 15 at the end of this report.

A description of the enquiry and the final results are presented in this paper.

## I. THE D.S.I.R. ENQUIRY

### COLLECTION OF DATA

The basic data were provided by two related enquiries. The first was designed to find out the numbers of persons regarded by their industrial employers as being employed full-time or part-time on research or development work. At the time when D.S.I.R. was framing its own questionnaire for this purpose it was learned that the Ministry of Labour and National Service was preparing a wider enquiry into the employment of scientists and engineers in private industry. For convenience, and to avoid the confusion which might have been caused by the distribution at nearly the same time of two rather similar questionnaires, it was arranged that the Social Survey should carry out a single enquiry on behalf of both Departments, using a single questionnaire.

The Social Survey sought information from all manufacturing establishments employing 500 workers or more, and from a sample of those employing between 100 and 499 workers. The sample was 1 in 4 of those employing between 200 and 499 workers, and 1 in 12 of those employing between 100 and 199. Establishments employing less than 100 workers were not approached. A total of 4379 questionnaires were sent out. Replies usable for the purposes of the D.S.I.R. enquiry were received from 3700 or about 85 per cent of the establishments invited to supply information, the proportion being rather higher among the smaller establishments than among the larger.

The results of the manpower enquiry provided data on the distribution of workers engaged on research and development. The second part of the enquiry was designed to link manpower with expenditure. The manpower questionnaire asked whether the establishment concerned kept any records of the costs of its research and development work, and if so, whether it would be willing to supply these figures to D.S.I.R. in confidence. D.S.I.R. then sent out further (expenditure) questionnaires to all those who replied in the affirmative to both these questions. The recipients were invited to complete one of two alternative questionnaires. The first was very simple: the figures asked for were the total expenditure on research and development, the numbers employed, and the cost of their wages and salaries. The second asked for more detailed figures of expenditure under various account heads. The British Iron and Steel Federation had carried out a special survey among its members, which produced information similar to that of the simpler of the two D.S.I.R. questionnaires.\*

Information on total expenditure on research and development, numbers employed, and wages and salary costs was collected from 238 firms, including those in the British Iron and Steel Federation membership. More detailed information on research and development expenditure was collected from another 94 firms which completed the more elaborate D.S.I.R. questionnaire. The replies to the D.S.I.R. questionnaires and the Federation survey taken together are estimated to have covered about one-half of the manpower employed on research and development in British industry, but the 94 returns which were subsequently used as the basis for calculating costs other than wages, covered rather less than a fifth.

The firms replying to the expenditure enquiry were not a statistical sample; they were volunteers, and the industrial coverage was incomplete. The data provided were used to construct an average total cost per person employed on research and development in private industry. This figure of £1300 was used in combination with the manpower estimates to produce estimates of expenditure on research and development in all manufacturing industries except aircraft. Expenditure on research and development in the aircraft industry was estimated independently.

For what it is worth, the evidence received from the volunteer firms suggests that no very great error is involved in using the average expenditure in all industries to estimate the expenditures in individual industries, provided that it is recognized that precise results cannot be expected.

#### DEFINITIONS

One of the more important decisions which faced the planners of the D.S.I.R. enquiry was the definition of research and development. It was realized from the outset that the terms would be construed in many different ways by different industries and by different units within industries. Considerable care was taken in drafting the definitions appended to the manpower questionnaire, and these were tried out in a pilot survey. Under research and development recipients were asked, "to include:

- (a) *basic and fundamental scientific research;*
- (b) *applied research, technical development and technical service work, including technical design work, done so as to;*

\* The questionnaires used in both parts of the survey are reproduced in Appendices I and II.

- (i) use different raw materials, or
- (ii) introduce new working methods, processes, machinery or products, or
- (iii) improve existing working methods, processes, machinery or products;

(c) prototype production,

and to exclude:

- (a) routine analyses, routine inspection, routine production testing and routine quality control;
- (b) detailed design of manufacturing units on the basis of information supplied by research;
- (c) tooling up and similar preparation for full scale production, after the development of new plant;
- (d) normal production for sale;
- (e) market research;
- (f) the pre-production of aircraft; and
- (g) the selling of an established product."

In the expenditure enquiry the recipients were invited to be even more specific about the types of work to which their expenditure figures related.

In spite of the apparent precision of these definitions, the data derived from different industries were not strictly comparable. It was realized from the outset that it would not be possible to distinguish research from development; but the same kind of difficulty arose in attempting to distinguish development from production. Different industries draw the line in different places. This is illustrated by the treatment of prototype design and development. In shipbuilding, and some highly specialized engineering industries where "one-off" production is the rule, there is nothing that is strictly synonymous with prototype development; the first ship, or the first machine of its kind, is charged to production, and the development work which went into it is treated as a normal cost of production. At the opposite extreme is the aircraft industry where not one, but several, prototypes may be produced and written off to development before a model goes into production. Between these extremes lie industries ranging from those older industries which are still partly governed by craft traditions to those in which mass or continuous process production has been extensively developed. In the former group, which includes textiles, boot and shoes, printing, and some sections of the engineering industries, the design of a new product or a new method of production is regarded as part of the craft, and in many firms may be treated as a normal cost of production. In the latter group the development stage, involving the construction of pilot plant or prototypes of new products, is more generally charged to development, though even this practice may vary from firm to firm. It is necessary to bear these considerations in mind when comparing, for example, the very large research and development expenditure attributed to the aircraft industry with the relatively smaller amount accredited to such an industry as shipbuilding.

#### ACCURACY

All the figures given in this report for manpower and expenditure employed on research and development are estimates. The basic data for manpower were derived from a wide sample and are, on the whole, more accurate than the expenditure figures. The latter, as already mentioned, were based on a calculation of cost per person employed.

As a means of estimating the total cost to all private industry of research and development carried out in industrial establishments, the method used probably involves less error than any alternative. It probably leads to under-estimation rather than to over-estimation, since it would appear that many firms do not attribute to their research and development expenditures the full overheads involved. It is, however, more difficult to be confident that the estimates of research and development expenditure for individual industries are within equally narrow margins of error.

## II. SUMMARY OF RESULTS

### GRAND TOTALS

The results of the survey indicated that, in 1955, private manufacturing industry of Great Britain employed the equivalent of 109 500 full-time workers on scientific research and technical development at a total cost of £183 million. Table 1 shows how these totals were divided between the main branches of manufacturing industry. A more detailed analysis is provided in Table 10.

Table 1. *Manpower and expenditure on research and development, 1955*  
*Distribution by main industries<sup>(1)</sup>*

	Manpower <sup>(2)</sup>		Expenditure <sup>(3)</sup>		
	Thousands	Per cent of total	£ million	Per cent of total	Per cent of total excluding aircraft
All manufacturing industries	109.5	100.0	183.2	100.0	—
All manufacturing industries excluding aircraft	79.4	72.5	103.2	56.3	100.0
Ceramics, glass, cement, etc.	1.4	1.3	1.8	1.0	1.7
Chemicals and allied trades	18.1	16.4	23.5	12.8	22.8
Metal manufacture	3.7	3.4	4.8	2.6	4.6
Non-electrical engineering and shipbuilding	11.7	10.7	15.3	8.4	14.8
Electrical engineering and electrical goods	25.7	23.4	33.4	18.2	32.4
Aircraft	30.1	27.5	80.0	43.7	—
Other vehicles and components	6.1	5.6	7.9	4.3	7.7
Metal goods not elsewhere specified	1.7	1.5	2.2	1.2	2.1
Precision instruments, etc.	1.4	1.3	1.9	1.0	1.8
Textiles	3.8	3.5	4.9	2.7	4.7
Leather, leather goods and fur	0.1	0.09	0.1	0.05	0.1
Clothing	0.1	0.09	0.1	0.05	0.1
Food, drink and tobacco	2.0	1.8	2.6	1.4	2.5
Manufactures of wood and cork	0.1	0.09	0.2	0.1	0.2
Paper and printing	1.4	1.3	1.9	1.0	1.8
Other manufacturing	2.2	2.0	2.8	1.5	2.7

(1) A more detailed analysis is provided in Table 10 at the end of this report.

(2) Part-time workers are included as equivalent number of full-time workers.

(3) Expenditure has been taken as £1300 per person employed, as shown in the first column, except in the case of the aircraft industry for which expenditure on research and development was separately estimated.

In 1955 manufacturing industry's contribution to the gross national product was £6535 million; expenditure on research and development, estimated at £183 million, represented 2.8 per cent of manufacturing industry's contribution. As Table 1 shows, nearly 44 per cent of the total expenditure on research and

development was accounted for by that of the aircraft industry. This very large expenditure is believed to have been financed mainly by Government defence contracts and not out of the private resources of the aircraft companies.

The development of military aircraft and the building of successive prototypes form a very large part of the business of the aircraft industry, and account for the high proportion of resources allocated to research and development. The estimated cost of research and development in 1955 was over one-third of the turnover of the industry (see Table 11). Unfortunately no separate data were available on which to base an estimate of cost of research and development devoted to civil aircraft. Government development contracts placed mainly for defence purposes contributed to the research and development activities of other engineering industries, but not to such an important extent. According to the estimates of the Advisory Council on Scientific Policy, the total contribution of defence contracts to research and development in private industry, including the aircraft industry, was £118·4 million.

Metal manufacturing and the engineering industries, including vehicles and aircraft, together accounted for 77 per cent of total expenditure on research and development. The chemical industry (including mineral oil refining) accounted for 13 per cent. All other industries taken together contributed only £17 million or 10 per cent of the total.

#### EMPLOYMENT ON RESEARCH AND DEVELOPMENT

From the manpower survey it was estimated that approximately 130,000 persons were engaged for the whole or part of their time on research and development activities in private manufacturing industry. Persons employed full-time were about 93 000; the total labour force has been taken as equivalent to 109 000 full-time workers, as shown in Table 1. Table 2 shows the distribution of full-time and part-time workers in the main industries.

Table 2. *Research and development manpower*  
*Distribution of full-time and part-time workers*

	Research and development workers			
	Total	Full-time	Part-time	
	Number	Number	Number	Per cent of total
All manufacturing industries	130 606	92 941	37 662	28·8
Ceramics, glass, cement, etc.	1 903	1 036	867	45·6
Chemicals and allied trades	21 948	14 810	7 138	32·5
Metal manufacture	4 989	2 724	2 265	45·4
Non-electrical engineering and shipbuilding	15 320	10 096	5 223	34·1
Electrical engineering	29 674	22 395	7 279	24·5
Aircraft	31 233	29 153	2 080	6·7
Other vehicles and components	7 367	4 847	2 520	34·2
Metal goods not elsewhere specified	2 851	1 207	1 645	57·7
Precision instruments, etc.	1 793	1 151	641	35·8
Textiles	4 626	1 637	2 989	64·6
Leather, leather goods and fur	281	31	249	88·6
Clothing	217	48	168	77·4
Food, drink and tobacco	3 044	1 474	1 570	51·6
Manufactures of wood and cork	373	88	285	76·4
Paper and printing	2 086	588	1 498	71·8
Other manufacturing	2 901	1 656	1 245	42·9

It will be observed that there is considerable variation in the proportion of workers who are employed full-time. The proportion appears to be higher in those industries which do more research and lower in those which do less, suggesting the obvious explanation that the more important research and development become the more they require specialist organization and staffing.

For the purpose of calculating expenditure, qualified as well as non-qualified workers employed part-time on research and development have been counted as the appropriate fractions of full-time workers. In comparing the contribution made by fully qualified scientists and engineers in different industries, however, it is probably more realistic to take the total number, whether employed full- or part-time. The peculiar contribution of the graduate, or equivalently qualified scientist or engineer, to industrial research is ideas and leadership and it is not unreasonable to assume that he may be contributing his full quota to the research and development effort, although in fact part of his time may be given up to management or production duties. Table 3 shows the total number of qualified scientists and engineers estimated to be employed in industry in all capacities, and also those who were estimated to be employed on research and development for some part of their time. The distribution is shown in more detail in Table 13. For the purposes of this analysis qualified scientists and engineers include, in addition to holders of university degrees, associates and graduate members of the institutions and professional bodies listed in the questionnaires reproduced in the appendices to this Report. Holders of the Higher National Certificate and Higher National Diploma are not included.

Table 3. *Distribution of qualified scientists and engineers*

	Total qualified scientists and engineers (*)	Employed on research and development			Ratio of scientists to engineers
		Total	Scientists	Engineers	
All manufacturing industries	48 829	29 196	14 855	14 341	51:49
Ceramics, glass, cement, etc.	752	565	344	221	61:39
Chemicals and allied trades	9 627	7 002	5 862	1 140	84:16
Metal manufacture	3 136	1 547	1 102	445	71:29
Non-electrical engineering and shipbuilding	8 352	3 389	802	2 587	24:76
Electrical engineering	12 198	7 557	2 977	4 580	39:61
Aircraft	4 259	3 600	600	3 000	17:83
Other vehicles and components	2 315	910	123	787	14:86
Metal goods not elsewhere specified	1 648	649	290	359	45:55
Precision instruments, etc.	761	535	200	335	37:63
Textiles	2 023	1 006	765	241	76:24
Leather, leather goods and fur			71	68	3
Clothing	50	14	9	5	64:36
Food, drink and tobacco	1 664	1 108	859	249	78:22
Manufactures of wood and cork	836	64	36	28	56:44
Paper and printing			440	284	156
Other manufacturing	1 208	738	534	204	72:28

(\*) The figures in this column are taken from the Report on Scientific and Engineering Manpower in Great Britain published by the Office of the Lord President of the Council and the Ministry of Labour and National Service in 1956. The Report showed that there were, in addition to the 48 829 scientists and engineers of graduate status, 22 290 holders of Higher National Certificate, Higher National Diploma, or equivalent qualifications.

The division of qualified staff between engineers and scientists shown in Table 3 follows the broad pattern that might be expected; engineers predominate in the metal-using industries and the chemical industries employ considerably more scientists than engineers. The chemical industries in fact employ two-fifths of all the scientists engaged on research and development in manufacturing industry. The high proportion of scientists among qualified staff employed in the textile industries is accounted for by the preponderance of scientists in the man-made fibre industries.

By comparing Table 3 with Table 1, it will be observed that the aircraft industry accounted for 44 per cent of total expenditure on research and development, but employed only 12 per cent of the qualified staff engaged in these activities.

The manpower questionnaire asked for qualified and other staff employed on research and development to be shown separately. It is probable that the identification of other staff with research and development varied considerably between the establishments included in the survey. For example where there was a separate research or development unit the return would presumably include all ancillary workers, such as clerical staff, industrial workers, cleaners, even gardeners and canteen workers; where research and development activities were not so clearly separated from production, the research staff may not have been assigned a proportionate share of the services enjoyed in common with other branches of the organization. Inspection of the returns, however, suggests that in spite of the possibilities for considerable variation, there was in fact a fairly consistent pattern. Table 4 shows the average number of supporting staff per qualified worker employed on research and development in the main industries.

Table 4. *Employment of supporting staff on research and development*

	Fully qualified staff <sup>(1)</sup>	Other staff <sup>(2)</sup>	Number
All manufacturing industries	29 196	85 080	1:3
Bricks, pottery, glass, cement, etc.	565	968	1:1½
Chemicals and allied trades	7 002	12 204	1:1½
Metal manufacture	1 547	2 474	1:1½
Non-electrical engineering and shipbuilding	3 389	9 217	1:2½
Electrical engineering	7 557	19 044	1:2½
Aircraft	3 600	26 500	1:7½
Other vehicles and components	910	5 339	1:6
Metal goods not elsewhere specified	649	1 193	1:2
Precision instruments, jewellery, etc.	535	960	1:2
Textiles	1 006	2 935	1:3
Leather, leather goods and fur	71	53	1:½
Clothing	14	77	1:5½
Food, drink and tobacco	1 108	1 288	1:1
Manufactures of wood and cork	64	119	1:2
Paper and printing	440	1 105	1:2½
Other manufacturing	738	1 604	1:2

(1) Total number employed whether full- or part-time.

(2) Part-time workers included as equivalent number of full-time workers.

## RESEARCH AND DEVELOPMENT ACTIVITY IN MANUFACTURING ESTABLISHMENTS OF DIFFERENT SIZES

All the data on manpower were derived from questionnaires addressed to manufacturing establishments. Industrial statistics are normally collected on this basis, and no other method was practicable. As would be expected, the presence of some research and development activity was more common in the larger than in the smaller establishments. But the method of collecting the data provided no basis for estimating the research and development effort of manufacturing companies. Large companies often own or control many manufacturing establishments (factories) and may concentrate their research and development in one or two, or even in an establishment devoted wholly to research. Some of these industrial research establishments are known to have been included in the manpower survey because they are officially classified as manufacturing establishments. The effect of their inclusion has been to swell the total number of research and development workers employed in smaller establishments, while some large establishments may have made nil returns or have shown very small numbers of research and development workers because they were served by separate facilities. For these reasons, analysis of the employment of research and development workers in establishments of different size can shed very little light upon the degree of concentration of industrial research in the larger manufacturing companies.

For what it is worth, however, the analysis of employment on research and development work by size of establishment shows that over half the research and development workers in the industries covered by the survey were in establishments employing 1000 persons or more in total. There were 683 of these establishments doing research and development, which between them employed the equivalent of about 37 700 workers on these activities. This average of 55 research and development workers per establishment compared with an average of five in the smallest establishments included in the survey.

### ORGANIZATION OF RESEARCH

As well as employing more workers in total the larger establishments also employed on their research and development a higher proportion of workers with graduate or equivalent qualifications, and a lower proportion of part-time workers. The extent to which research and development has become an organized activity is further illustrated in Table 5.

There were, as has already been observed, a large number of establishments employing very few research workers: 2031 establishments employing 10 or fewer workers on their research and development activities. But these establishments accounted for only 8 per cent of all the research and development workers in industry; 80 per cent of the total were employed in establishments whose research and development staff numbered more than 50 persons. There were comparatively few of these latter establishments: only 309 in the whole of the industry. Research and development effort carried out on any scale is apparently concentrated in relatively few large organizations.

Subsequent to the survey an attempt was made to estimate the research expenditure of the largest manufacturing groups in the country. The results of this attempt suggested that 58 companies or groups accounted for about one-third of the total expenditure on research and development in private industry—approximately £60 million out of £180 million.

Table 5. Employment of research and development workers

Number per establishment  
(All industries)

Research and development workers per manufacturing establishment	Manufacturing establishments (%)		Research and development workers (%)	
	Number	Per cent of total	Number	Per cent of total
One or more . . .	2 793	100.0	96 400	100
1-5 . . .	1 588	56.8	4 100	4
6-10 . . .	443	15.9	3 600	4
11-25 . . .	293	10.5	5 100	5
26-50 . . .	160	5.7	6 100	6
51-100 . . .	124	4.4	8 900	9
101-200 . . .	90	3.2	13 300	14
201-300 . . .	34	1.2	9 000	9
301-500 . . .	24	0.9	9 200	10
501-1000 . . .	27	1.0	20 400	21
1001- and over . . .	10	0.4	16 700	17

(C) Establishments employing 100 or more persons; some establishments devoted entirely to research are included.

(E) Estimated number of workers spending half or more of their time on research and development. Part-time workers spending less than half their time on these activities have been excluded from this distribution.

## EXPENDITURE PER HEAD

Information on expenditure on research and development was received from 332 manufacturing companies, including the members of the British Iron and Steel Federation, which conducted a separate enquiry but agreed to allow D.S.I.R. to use the results. The co-operation of the British Iron and Steel Federation meant that the coverage of that industry was better than that of any other. The method of treating the data derived from the returns was designed to overcome, as far as possible, the defective coverage of some industries. As already mentioned, the returns were made voluntarily as the result of the invitation included in the manpower-survey questionnaire; they did not, therefore, provide a true statistical sample and could be presumed to represent industrial undertakings to whom research and development were important activities and to exclude a larger number of undertakings to whom research and development were more of a sideshow. However, it seemed reasonable to use the figures provided by the co-operating firms to calculate a cost per head of research and development workers.

Data on wages and salaries were provided by 332 returns covering firms in all sections of industry, except aircraft. The variation in average wages and salaries between different industrial groups is of some interest, and is shown in Table 14. For the purpose of calculating expenditure throughout industry the average of £720 per person employed on research and development was used. Data on costs other than staff and labour were provided by 94 returns. These returns showed that the second largest element in total cost per person employed was materials and equipment (including depreciation), which averaged £300 per person. After

calculating allowances for all other expenses, including gas, electricity and water, rent, rates and insurance, maintenance, and office and administrative expenses, a total cost of approximately £1300 per person was reached. This figure of £1300 was multiplied by the number of research and development workers estimated to be employed, to give an estimate of the total cost of research and development activity in all manufacturing industries other than aircraft.

#### COMPARISON BETWEEN INDUSTRIES

The amount of research and development which an industry will do must depend very largely upon its need for more scientific knowledge, and the extent to which it can apply it. The resources allocated to development will also depend, as has been suggested above, on the extent to which the method of prototype development is used and regarded as a separately identifiable function. The processes and operations of much of the chemical industry, the synthetic fibre industry and large sections of the engineering industries are based on science, and to a very large extent on the scientific discoveries of recent years. Scientific research and technological development are essential to their competitive survival. At the other extreme the clothing industry, some of the food industries, and the industries using timber as their raw material may never develop a very elaborate technology, and there may be a more limited area in which scientific research can improve their operations or their products. In some industries scientific and engineering skills are best applied more directly to the productive processes. The wide differences between research and development expenditure in different industries may in some cases reflect these facts rather than lack of enterprise or scientific education on the part of industrialists. In comparing an industry's research expenditure with some measure of its size such as its turnover, net output, or employment, the purpose of the comparison is not to award praise or blame to large or small spenders on research, but rather to provide some yardstick by which individual companies or establishments may measure their own performance in relation to the average for their own industry.

It is believed that a firm wishing to compare its own research and development effort with that of other firms in the same industry would do this by examining the relationship between research and development expenditure and turnover. Estimates of the turnover of some industries can be derived from the Board of Trade Census of Production for 1955. In Table 11 the estimated expenditures on research and development of establishments employing 100 persons or more in selected industries are shown as percentages of their estimated turnovers. This calculation can reasonably be done for separate industries. Difficulties arise, however, when the turnovers of different industries are added together: the sales of one industry often provide part of the raw material for another, and the combined total turnover will include some double counting. Estimates of the extent of sales from one industry to another are not available for 1955.

For purposes of comparing the performances of one group of industries with another, a more convenient measure is the ratio of research and development expenditure to net output. The net output of an industry is its gross output less the value of materials and fuel used, and represents the income generated or value added to raw materials by that industry. Net outputs can conveniently be added together, without duplication, to represent the contribution made by groups of industries to the economy. In Table 6 the estimated research and development expenditures of the main industries are shown as percentages of their net output.

The estimated expenditure per person employed has been shown in the same table as another possible way of comparing one industry with another, eliminating the factor of size.

Table 6. *Research expenditure compared with net output and employment of establishments employing 100 or more persons\**

	Research and development expenditure	
	Per cent of net output	Per person employed
All manufacturing industries	3.5	30
All industries except aircraft	2.0	17
Bricks, pottery, glass, cement, etc.	1.0	8
Chemicals and allied trades	4.8	70
Metal manufacture	0.9	9
Non-electrical engineering and shipbuilding	1.8	16
Electrical engineering	6.8	56
Aircraft	35.1	354
Other vehicles and components	1.7	14
Metal goods not elsewhere specified	0.8	7
Precision instruments, Jewellery, etc.	2.3	21
Textiles	1.0	7
Leather, leather goods and fur	0.6	4
Clothing	0.1	0.3
Food, drink and tobacco	0.6	5
Manufactures of wood and cork	0.2	2
Paper and printing	0.5	5
Other manufacturing	1.8	13

\* Estimates of expenditure on research and development are for establishments employing 100 persons or more in total. Estimates of turnover, net output and employment used for the purposes of this report also refer to establishments employing 100 persons or more.

Inspection of the ratios shows a pattern very similar to that provided by the gross expenditures shown in Table 1. The aircraft industry still heads the list; clothing, manufactures of wood and cork, textiles, and the food industries still appear near the bottom of the list. The electrical engineering industries spent a higher proportion of their resources on research and development than any other group of industries, except aircraft. Within the electrical group (see Table 11) the industries producing electrical machinery and radio and telecommunications equipment were the heaviest proportionate spenders; these industries, of course, are known to do a great deal of research, and they are also industries in which Government contracts are an important source of funds for development. In Table 12 selected industries have been arranged in order according to the proportion of their net output allocated to research and development.

#### OTHER RESEARCH RESOURCES AVAILABLE TO INDUSTRY

The estimates of research and development expenditure derived from the survey include, in addition to the work done in manufacturing establishments, a certain number of establishments run by private industry entirely for research purposes. Some of these are run by manufacturing companies for the exclusive use of their own enterprises; others may be run co-operatively by a group of companies in an industry. The grant-aided research associations<sup>(1)</sup> in the Government scheme were, however, specifically excluded from the survey and from the estimates based upon the results; so also was research done by Government establishments and by nationalized industries.

(1) Co-operative, non-profit making, industrial associations for research aided by grants from D.S.I.R.

For some industries, therefore, the estimates of research and development expenditure derived from the survey give an incomplete picture of the resources available. This is particularly true of some of the industries whose expenditure appears to be very low in relation to the average. Table 7 shows the total estimated expenditure by industry on research and development including the expenditure attributable to research associations and to appropriate research stations of the Department of Scientific and Industrial Research.<sup>(1)</sup>

Table 7. *Expenditure on research and development in manufacturing establishments, grant-aided research associations and D.S.I.R. stations. Distribution between main industries*

	Total	By industry in own establishments	By research associations and D.S.I.R. stations	£'000
All manufacturing industries . . .	192.1	183.2	8.9	
Bricks, pottery, glass, cement, etc. . .	2.3	1.8	0.5	
Chemicals and allied trades . . .	24.2	23.5	0.7	
Metal manufacture . . .	6.0	4.8	1.2	
Non-electrical engineering and shipbuilding . . .	17.8	15.3	2.5	
Electrical engineering . . .	34.3	33.4	0.9	
Aircraft . . .	80.0	80.0	—	
Other vehicles and components . . .	8.0	7.9	0.1	
Metal goods not elsewhere specified . . .	2.2	2.2	0.03	
Precision instruments, jewellery, etc. . .	2.3	1.9	0.4	
Textiles . . .	6.0	4.9	1.1	
Leather, leather goods and fur . . .	0.2	0.1	0.1	
Clothing . . .	0.2	0.1	0.1	
Food, drink and tobacco . . .	3.4	2.6	0.8	
Manufactures of wood and cork . . .	0.4	0.2	0.2	
Paper and printing . . .	2.1	1.9	0.2	
Other manufacturing . . .	2.9	2.8	0.1	

Research associations and D.S.I.R. provided about 5 per cent of the total; if the aircraft industry is excluded the ratio is 8 per cent.

The contribution of outside organizations to the research resources available varies very considerably from industry to industry. The industries to which they were heavy contributors are shown in more detail in Table 8.

In the large and important shipbuilding and marine-engineering industry over 80 per cent of research, separately identified and defined as such, appears to have been done by research associations and Government stations. In the textile industries, other than the synthetic-fibre industry, over 50 per cent of research was done by research associations. In metal manufacture (iron and steel and non-ferrous metals) nearly one-fifth of the research was carried out by research associations. A number of the industries which did the least research on their own behalf—boots and shoes, textiles, manufactures of wood and cork, and leather—were served by research associations and, in the case of manufactures of wood, by a D.S.I.R. station also.

(1) To the cost of the D.S.I.R. stations carried on the D.S.I.R. Vote has been added an allowance to cover expenses carried on the Votes of other departments and charges such as rent, rates and insurance which would be applicable if the stations were privately owned.

Table 8. *Industries in which grant-aided research associations and D.S.I.R. stations made important contributions to total research and development resources*

	Expenditure on research and development			
	Total	By industry in own establishments	By research associations and D.S.I.R. stations	R.A.s. and D.S.I.R. as per cent of total
£ 000	£ 000	£ 000	£ 000	Per cent
Shipbuilding and marine engineering . . .	1209	233	976	81
Boots and shoes . . .	99	33	66	67
Linen, jute, hosiery and knitwear and lace . . .	330	130	200	61
Wool and worsted . . .	398	169	229	58
Cotton . . .	670	293	377	56
Manufactures of wood and cork . . .	421	190	231	55
Leather, leather goods and fur . . .	162	100	62	38
Ceramics . . .	570	389	181	32
Cement, coated roadstone, abrasives, etc. . .	960	690	270	28
Iron foundries . . .	788	590	198	25
Scientific, surgical and photographic instruments . . .	2043	1616	427	21
Iron and steel . . .	3259	2608	651	20
Non-ferrous metals . . .	1972	1622	350	18

#### REGIONAL DISTRIBUTION OF RESEARCH AND DEVELOPMENT

The regional distribution of research and development workers does not correspond very closely with the regional distribution of the total industrial labour force. Table 9 shows the proportional distribution of research and development manpower, total industrial manpower, and total population between the main regions of England, Scotland and Wales.

Table 9. *Regional distribution of research and development workers, total industrial labour force and total population*

	Research and development workers in private industry	Total industrial labour force	Total population
		Per cent 100-0	Per cent 100-0
Great Britain . . . .	Per cent 100-0	Per cent 100-0	Per cent 100-0
England			
London and South-Eastern . . . .	28.8	19.9	22.1
Eastern . . . .	9.5	5.1	6.7
Southern . . . .	7.1	3.9	5.7
South-Western . . . .	9.1	4.1	6.2
Midlands . . . .	13.1	14.2	9.1
North Midlands . . . .	5.9	7.6	7.0
East and West Riding of Yorkshire . . . .	5.3	10.1	8.3
North-Western . . . .	13.8	17.2	13.0
Northern . . . .	3.1	5.2	6.4
Scotland . . . .	2.7	9.1	10.4
Wales . . . .	1.7	3.6	5.3

London and the South-Eastern, Eastern, Southern and South-Western regions of England contain more than half the research and development workers, but only one-third of the total industrial labour force and 41 per cent of the population. If workers in grant-aided research associations and D.S.I.R. stations were to be included, the concentration of research in Southern England would appear even more pronounced, as many of these institutions are located in London and the home counties.

One of the main reasons for the apparent concentration of research and development in the south is the location of most of the aircraft industry, the radio industry and the newer developments of electrical engineering in Southern England. Another contributory reason is that some of the largest manufacturing companies with head offices in London have in recent years established separate research laboratories in country districts in Southern England, although their manufacturing interests may be more widely scattered.

Table 10. *Employment and expenditure on research and development in manufacturing industries*

Standard Industrial Classification Number <sup>(1)</sup>		Persons employed on research and development <sup>(2)</sup>	Expenditure on research and development <sup>(3)</sup>
			Number
	ALL MANUFACTURING INDUSTRIES . . .	109 493	183 211
	ALL MANUFACTURING INDUSTRIES EXCEPT AIRCRAFT . . . .	79 393	103 211
III	TREATMENT OF NON-METALLIFEROUS MINING PRODUCTS OTHER THAN COAL . . .	1 369	1 780
30	Bricks and fireclay goods . . . .	152	198
21	China and earthenware . . . .	147	191
22, 23	Glass . . . .	539	701
24, 29	Cement & other non-metal mining products . . . .	531	690
IV	CHEMICALS AND ALLIED TRADES . . .	18 102	23 533
32	Pharmaceutical and toilet preparations . . .	1 381	1 795
34	Paint and varnish . . . .	1 036	1 347
35	Soap, candles, glycerine, polishes, ink, matches . . . .	1 234	1 604
36	Mineral oil refining . . . .	2 725	3 543
30, 31, 33, 39	Other chemicals . . . .	11 726	15 244
V	METAL MANUFACTURE . . .	3 708	4 820
42	Iron foundries . . . .	454	590
40, 41, 43, 44	Other iron and steel smelting, rolling, etc. .	2 006	2 608
49	Non-ferrous metals, smelting, rolling, etc. .	1 248	1 622
VI	ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS . . .	37 436	48 667
	(i) <i>Non-electrical engineering</i>	11 733	15 253
50, 51	Shipbuilding, repairing and marine engineer- ing . . .	179	233
52	Agricultural machinery (excluding tractors) . .	312	406
53	Boilers and boilerhouse plant . . .	549	714
54	Machine tools . . . .	589	766
55	Stationary engines . . . .	451	586
56	Textile machinery and accessories . . .	304	395
58	Constructional engineering . . . .	165	215
57, 69	Ordnance and other non-electrical engineer- ing . . . .	9 184	11 939
	(ii) <i>Electrical goods</i>	25 703	33 414
70	Electrical machinery . . . .	9 865	12 825
71	Electrical wires and cables . . . .	911	1 184
72-74	Radio and telecommunications . . . .	10 731	13 950
75, 79	Other electrical goods . . . .	4 196	5 455

Table 10. *Employment and expenditure on research and development in manufacturing industries—continued*

Standard Industrial Classification Number <sup>(1)</sup>		Persons employed on research and development <sup>(2)</sup>	Expenditure on research and development <sup>(3)</sup>
			Number
VII	VEHICLES	36 173	87 895
80	Manufacture of motor vehicles and cycles	2 754	3 580
82	Manufacture and repair of aircraft	30 100 <sup>(4)</sup>	80 000 <sup>(4)</sup>
83	Parts and accessories for motor vehicles and aircraft	3 217	4 182
81, 84-89	Other vehicle industries	102	133
VIII	METAL GOODS NOT ELSEWHERE SPECIFIED	1 659	2 157
90	Tools and cutlery	141	183
91	Bolts, nuts, screws, rivets, nails, etc.	195	254
93	Wire and wire manufactures	77	100
94	Hollow-ware	460	598
95	Brass manufactures	137	178
92, 99	Metal industries not elsewhere specified	649	844
IX	PRECISION INSTRUMENTS, JEWELLERY, ETC.	1 426	1 854
100	Scientific, surgical, photographic instruments, etc.	1 243	1 616
101, 103	Manufacture and repair of watches, clocks and musical instruments	175	228
102	Jewellery, plate and refining of precious metals	8	10
X	TEXTILES	3 750	4 875
110	Cotton spinning, doubling, etc.	83	108
111	Cotton weaving, etc.	142	185
112	Woollen and worsted	130	169
113, 114	Artificial fibres	2 503	3 254
120	Carpets	88	114
123	Textile finishing	240	312
115-119, 121,	Linen, jute, rope, hosiery, lace, narrow fabrics and made-up textiles	100	130
122		464	603
129	Asbestos and other textiles		
XI	LEATHER, LEATHER GOODS AND FUR	77	100
XII	CLOTHING	83	108
148	Manufacture of boots, shoes, etc. (not rubber)	25	33
140-147, 149	Tailoring and other clothing	58	75

Table 10. Employment and expenditure on research and development in manufacturing industries—continued

Standard Industrial Classification Number <sup>(1)</sup>		Persons employed on research and development <sup>(2)</sup>	Expenditure on research and development <sup>(3)</sup>	
			Number	£ 000
XIII	FOOD, DRINK AND TOBACCO . . .	1 979		2 573
152	Biscuits . . .	70		91
155	Sugar and glucose . . .	157		204
156	Cocoa, chocolate and sugar confectionery . . .	391		508
157	Preserving of fruit and vegetables . . .	174		226
150, 151, 153, 154, 162	Other food industries . . .	691		898
163	Brewing and malting . . .	142		185
164, 168	Other drink industries . . .	164		213
169	Tobacco . . .	190		247
XIV	MANUFACTURES OF WOOD AND CORK . . .	146		190
170	Timber . . .	21		27
171, 172, 173	Furniture and upholstery . . .	112		146
179	Other wood and cork manufactures . . .	13		17
XV	PAPER AND PRINTING . . .	1 428		1 856
180, 181	Paper, board and wallpaper . . .	671		872
182	Cardboard and fibre-board boxes, etc. . .	58		75
183	Other manufactures of paper and board, etc. . .	36		47
186, 189	Printing, publishing, bookbinding . . .	663		862
XVI	OTHER MANUFACTURING INDUSTRIES . . .	2 157		2 804
190	Rubber . . .	1 266		1 646
191	Linoleum, leather cloth, etc. . .	181		235
192	Brushes and brooms . . .	6		8
193, 194	Toys, sports requisites and miscellaneous stationers goods . . .	54		70
195	Production and printing of cinematograph films . . .	57		74
199	Miscellaneous manufacturing industries . . .	593		771

(<sup>1</sup>) The Standard Industrial Classification is a classification of British industries according to the nature of their output. It is used by all Government departments for statistical purposes.

(<sup>2</sup>) Part-time workers included as appropriate fraction of full-time workers.

(<sup>3</sup>) Expenditure at £1300 per person employed on research and development as shown in the previous column.

(<sup>4</sup>) Manpower and expenditure in the aircraft industry were estimated independently.

Table 11. *Estimated expenditure on research and development in selected industries compared with total employment, turnover and net output*

Standard Industrial Classification Number		Expenditure on research and development			
		Total	Per person employed in industry	Per cent of turnover	Per cent of net output
		£ 000	£	%	%
20	Brick and fireclay . . .	198	4.5	0.3	0.6
21	China and earthenware . . .	191	2.9	0.4	0.5
32	Drugs and pharmaceutical preparations . . .	1 795	38.4	1.6	3.1
34	Paint and varnish . . .	1 347	53.7	1.6	3.8
36	Mineral oil refining . . .	3 543	139.5	1.1	7.5
42	Iron foundries . . .	590	6.1	0.4	0.8
49	Non-ferrous metals (smelting, rolling, etc.) . . .	1 622	15.7	0.3	1.4
50, 51	Shipbuilding, ship-repairing and marine engineering . . .	233	1.1	0.1	0.1
54	Machine tools . . .	766	9.8	0.7	1.1
56	Textile machinery and accessories . . .	395	8.2	0.6	0.9
52, 55, 57 (part) and 69 (part)	Mechanical engineering (general) . . .	13 856	21.8	1.3	2.6
70 and 79 (part)	Electrical engineering (general) . . .	18 280	58.2	3.2	6.2
71	Electric wires and cables . . .	1 184	20.4	0.7	2.6
72, 73 and 74	Radio and telecommunications . . .	13 950	61.6	4.8	9.3
80 and 83 (part)	Motor vehicles and cycles (manufacturing) . . .	3 580	11.9	0.3	0.9
82 and 83 (part)	Aircraft manufacture and repair . . .	80 000	353.7	19.4	35.1
91, 92 and 99(4)	Chain, nail, screw and miscellaneous forgings . . .	254	7.2	0.2	0.4
93	Wire and wire manufactures . . .	100	3.2	0.1	0.4
100	Scientific, surgical and photographic instruments . . .	1 616	27.5	1.8	3.1
110	Cotton spinning and doubling . . .	108	0.9	0.04	0.2
111	Cotton weaving . . .	185	2.2	0.1	0.5
112	Woollen and worsted . . .	169	1.1	0.04	0.1
113, 114	Rayon, nylon, etc., and silk . . .	3 254	41.7	1.6	4.1
123	Textile finishing . . .	312	5.3	0.4	0.8
140-147, 149	Tailoring, dressmaking, etc. . .	74	0.3	0.02	0.1
148	Boot and shoe . . .	33	0.4	0.02	0.1
156	Cocoa, chocolate and sugar confectionery . . .	508	5.4	0.2	0.8
163	Brewing and malting . . .	185	2.7	0.1	0.2
169	Tobacco . . .	247	6.9	0.02	0.4
170	Timber . . .	44	0.7	0.1	0.2
180, 181	Paper and board . . .	872	10.1	0.3	0.8
186, 189	Newspaper and periodical printing; other printing, bookbinding, etc. . .	862	4.2	0.2	0.5
190	Rubber . . .	1 646	15.6	0.7	1.9

Table 12. Selected industries placed in order of expenditure on research and development, expressed as a proportion of net output

Expenditure as a proportion of net output (per cent)		Standard Industrial Classification Number
Over 10	Aircraft	82
9.9-5.0	Electrical machinery	70
	Radio and telecommunications	72-74
	Soap, candles, glycerine, polish, ink, matches	35
	General chemicals	30, 31, 33 & 39
	Mineral oil refining	36
4.9-2.5	Other electrical goods (domestic appliances, etc.)	75, 79
	Paint and varnish	34
	Artificial fibres	113, 114
	Boilers and boilerhouse plant	53
	Scientific, surgical and photographic instruments, etc.	100
	Pharmaceutical preparations, toilet preparations, perfumery	32
	Ordnance, small arms and general non-electrical engineering	57, 69
	Stationary engines	55
	Parts and accessories for motor vehicles and aircraft	83
2.4-1.0	Plastics, photographic films, etc.	199
	Electrical wires and cables	71
	Rubber	190
	Hollow-ware	94
	Linoleum, leather cloth, etc.	191
	Watches, clocks and musical instruments	101 & 103
	Non-ferrous metals, smelting, rolling, etc.	49
	Glass	22 & 23
	Manufacture of motor vehicles and cycles	80
	Machine tools	54
0.99-0.5	Textile machinery and accessories	56
	Tools and cutlery	90
	Carpets	120
	Cocoa, chocolate and sugar confectionery	156
	Iron foundries	42
	Other iron and steel	40, 41, 43, 44
	Textile finishing, etc.	123
	Production and printing of cinematograph films	195
	Sugar and glucose	155
	Printing, publishing, book-binding, engraving, etc.	186 & 189
	Bricks and fireclay goods	20
	Paper, board and wallpaper	180 & 181
	China and earthenware	21
	Other drink industries	164 & 168
0.49-0.20	Preserving of fruit and vegetables	157
	Cotton weaving, etc.	111
	Tobacco	169
	Wire and wire manufactures	93
	Furniture and upholstery	171
	Brewing and malting	163
	Timber	170
	Cotton spinning, doubling, etc.	110
0.19 or less	Biscuits	152
	Shipbuilding and marine engineering	50, 51
	Woollen and worsted	112
	Tailoring and other clothing industries	140-147 & 149
	Manufacture of boots, shoes, etc.	148

Table 13. Persons employed on research and development: analysis by industry and type of worker

Standard Industrial Classification Number			SCIENTISTS		ENGINEERS		OTHER EMPLOYEES		TOTAL	
			Total	As full-time workers	Total	As full-time workers	Total	As full-time workers	All workers	As full-time workers
			ALL MANUFACTURING INDUSTRIES (excluding aircraft)		MINING PRODUCTS		1,338		1,903	
III			14,255	12,151	11,341	8,673	73,777	58,589	99,373	79,393
20			344	253	221	146	1,338	968	1,903	1,369
21			57	21	15	4	191	127	263	152
22 and 23			34	21	30	16	252	109	316	147
24 and 29			174	144	107	89	385	305	646	539
			79	67	70	37	511	427	660	531
IV			5,862	5,059	1,140	841	14,946	12,204	21,948	18,107
32			503	465	35	15	1,450	901	1,988	1,381
34			317	275	32	28	936	733	1,285	1,036
35			375	328	116	88	1,049	819	1,540	1,234
36			715	676	296	263	1,933	1,787	2,944	2,725
30, 31, 33 and 39			3,952	3,315	661	447	9,577	7,964	14,190	11,726
V			1,102	941	445	293	3,442	2,474	4,989	3,708
42			77	59	45	25	567	370	689	454
40, 41, 43 and 44			526	481	254	196	1,803	1,329	2,583	2,006
49			500	401	146	72	1,072	775	1,718	1,248

VI	ENGINEERING, SHIPBUILDING AND ELECTRICAL GOODS	3 779	5 688	28 261	44 994	37 436
50 and 51	(i) Non-electrical engineering	802	691	1 825	11 930	9 217
	Shipbuilding, repairing and marine engineering	7	3	112	66	109
	Agricultural machinery (excluding tractors)	1	1	50	28	310
52	Boilers and boilerhouse plant	41	37	86	56	455
53	Machine tools	90	57	231	106	791
54	Stationary engines	37	33	154	145	318
55	Textile machinery and accessories	11	11	69	60	283
56	Constructional engineering	47	32	97	67	160
58	Ordnance and other non-electrical engineering	569	517	1 789	1 297	9 089
57 and 69	(ii) Electrical goods	2 977	2 796	3 863	22 117	19 044
	Electrical machinery	1 253	1 212	1 912	1 540	7 737
70	Electrical wires and cables	227	199	126	95	783
71	Radio and telecommunications	1 026	976	1 785	1 646	9 769
72, 73 and 74	Other electrical goods	470	409	759	582	3 828
75 and 79	vehicles (excluding aircraft)	123	92	787	642	6 457
	Manufacture of motor vehicles and cycles	45	28	240	212	3 106
80	Parts and accessories for motor vehicles and aircraft	75	64	445	385	3 226
83	Other vehicle industries	3	—	102	45	125
81, 84-89	METAL GOODS NOT ELSEWHERE SPECIFIED	290	236	359	232	2 202
VII	Tools and cutlery	22	15	35	28	138
90	Bolts, nuts, screws, rivets, nails, etc.	15	11	33	26	330
91	Wire and wire manufactures	33	18	40	18	174
93	Hollow-ware	90	90	45	33	488
94	Brass manufactures	18	12	37	22	363
95	Metal industries not elsewhere specified	113	90	169	105	710
92 and 99	PRECISION INSTRUMENTS, JEWELLERY, ETC.	200	165	335	302	1 258
100	Scientific, surgical and photographic instruments	178	152	293	271	1 095
101 and 103	Manufacture and repair of watches, clocks and musical instruments	9	9	37	29	821
102	Jewellery, plate and refining of precious metals	13	4	4	2	4
						2
						21
						8

Table 13. Persons employed on research and development: analysis by industry and type of worker—continued

Standard Industrial Classification Number	X	SCIENTISTS		ENGINEERS		OTHER EMPLOYEES		TOTAL	
		As full-time workers		As full-time workers		As full-time workers		All workers	
		Total	As full-time workers	Total	As full-time workers	Total	As full-time workers	Total	As full-time workers
110	TEXTILES	765	651	241	168	3 620	2 935	4 626	3 750
111	Cotton spinning, doubling, etc.	18	5	6	2	157	77	181	83
112	Cotton weaving, etc.	52	44	10	4	160	94	222	142
113 and 114	Woollen and worsted	36	21	26	11	212	98	274	130
120	Artificial fibres	440	423	85	69	2 060	2 011	2 585	2 503
123	Carpets	8	2	11	7	88	80	107	88
115-119 and 121-122	Textile finishing	118	64	23	12	380	165	521	240
129	Linen, jute, rope, hosiery, lace, narrow fabrics and made-up textiles	17	16	10	2	163	82	190	100
	Asbestos and other textiles	77	76	71	61	400	328	548	464
XI	LEATHER, LEATHER GOODS AND FUR	68	23	3	1	210	53	281	77
XII	CLOTHING	9	5	5	1	203	77	217	83
148	Manufacture of boots, shoes, etc. (not rubber)	5	1	—	—	100	23	105	25
140-147, 149	Tailoring and other clothing industries	4	4	—	—	103	54	112	58
XIII	FOOD, DRINK AND TOBACCO	859	576	249	116	1 936	1 288	3 044	1 979
152	Biscuits	38	17	15	7	68	47	121	70
155	Sugar and glucose	60	54	25	117	78	242	157	391
156	Cocoa, chocolate and sugar confectionery	198	102	56	36	379	253	633	391
157	Preserving of fruit and vegetables	51	28	21	8	215	138	287	174
150, 151, 153, 154 and 162	Other food industries	308	242	42	24	671	424	1 021	691

163	Brewing and malting	142
164 and 168	Other drink industries	164
169	Tobacco	190
XIV	MANUFACTURES OF WOOD AND CORK	146
170	Timber	71
171	Furniture and upholstery	43
172, 173 and 179	Other wood and cork manufactures	88
		46
		34
		23
		2
		24
		11
		131
		153
		204
		5
		23
		24
		119
		309
		14
		28
		3
		24
		13
		2
		24
		12
		10
		24
		110
		373
		146
XV	PAPER AND PRINTING	
180 and 181	Paper, board and wallpaper	284
182	Cardboard and fibre-board boxes, etc.	214
183	Other manufactures of paper and board	27
189	Printing, publishing, bookbinding, etc.	40
		223
		156
		103
		1646
		1105
		2086
		1428
XVI	OTHER MANUFACTURING INDUSTRIES	
190	Rubber	534
191	Linoleum, leather-cloth, etc.	426
192	Brushes and brooms	298
193 and 194	Toys, sports requisites and miscellaneous stationers goods	81
195	Production and printing of cinematograph films	2
199	Miscellaneous manufacturing industries	18
		61
		1
		2
		14
		4
		1
		6
		129
		126
		204
		1604
		2163
		1601
		2157
		963
		1350
		145
		108
		12
		3
		19
		181
		243
		6
		54
		79
		55
		91
		439
		687
		593

Table 14. *Average remuneration of persons employed in research and development*  
*analysis of main industries*

	£ per person per annum
All manufacturing industries (except aircraft)	720
Ceramics, glass, cement, etc.	683
Chemical and allied trades	776
Metal manufacture	681
Non-electrical engineering and shipbuilding	694
Electrical engineering	638
Vehicles and components	762
Metal goods not elsewhere specified	729
Precision instruments, etc.	653
Textiles	653
Leather, leather goods and fur	858
Clothing	688
Food, drink and tobacco	699
Paper and printing	699
Other manufacturing	699

Table 15. *Expenditure on research and development in Great Britain, 1955-56 (£ million)*

Major Sectors	Cost of Research and Development Carried Out in Each Sector							Percentage (11)
	Government		Nationalized Industry		Research Associations		Universities	
	Defence	Civil	Departments	Research Councils	Private Industry	Other (a)	Total finance	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
S 1. Government (b)								
O (i) Defence	58.2	—	0.3	—	118.4	—	0.6	—
U (ii) Civil : Departments	0.5	12.2	0.2	0.1	8.1	1.6	9.8(c)	3.5
R Research councils	—	—	8.7(d)	—	0.1	1.4	0.2	12.0
C Total	58.7	12.2	9.2	0.2	126.6	1.6	11.8	3.7
E 2. Nationalized industry	—	—	—	—	3.8	—	0.1	—
S 3. Private industry	5.0	0.1	0.8	—	58.4	3.2	0.8	0.3
F 4. Universities	—	—	—	—	—	—	0.5(e)	—
U 5. Other organizations (d)	2.0	—	—	—	—	—	1.2(e)	n.a.
N 6. Cost of research and development carried out in each sector	65.7	12.3	10.0	4.0	187.0	4.9	14.4	3.7
D 7. Percentage	21.9	4.1	3.3	1.3	61.7	1.6	4.8	1.2

(a) Includes public foundations, grant-aided institutions, professional societies, local authorities, foreign governments, etc.

(b) Includes the United Kingdom Atomic Energy Authority.

(c) Includes £7.5 millions from general purposes grants and £2 millions for capital works.

(d) Includes £1 million on Agriculture Research Council and Medical Research Council units attached to universities.

(e) Expenditure financed from fees, donations, private income, etc., in pure science and technology.

Note: All the estimates in this table are shown to more significant figures than is justified, in order to show how the totals have been computed. The period to which the figures relate is not, in all cases, exactly the financial year 1955-56.

## APPENDIX I

QUESTIONNAIRE SENT OUT BY THE SOCIAL SURVEY ON BEHALF OF THE  
MINISTRY OF LABOUR AND NATIONAL SERVICE AND THE DEPARTMENT  
OF SCIENTIFIC AND INDUSTRIAL RESEARCH

S.S. 230

--

THE SOCIAL SURVEY  
Montagu Mansions (Block 1),  
Crawford Street,  
Baker Street, London, W.1.

1. What was the number on the pay-roll of this establishment as given in your last return to the Ministry of Labour?  

Number on pay roll
2. Do you:  
(a) Employ any qualified scientists or engineers at this establishment?  
YES/NO
3. Does your firm or group own a separate research establishment which is not a part of any factory or other productive establishment? YES/NO  
If so, please give its name and address here.  

Name and address of separate research establishment

4. Does your firm or group keep any figures for the cost of its research and/or development work? YES /NO

If so, would you be willing to supply some figures to D.S.I.R. in confidence? YES/NO

If so, please give here the name and address to which D.S.I.R. should send its enquiry.

5. In Table I we are asking you to give the numbers of your scientists and engineers qualified in each subject, allocated to their main work. No employee should be counted more than once. Persons holding a qualification in more than one branch of science or engineering should be recorded under the branch appropriate to the work in which they are at present engaged. Please include, in addition to employees, all full-time directors and working proprietors with relevant qualifications.

Under 'Biologist' please include holders of a university degree with a biological subject as a principal subject. Under 'Mechanical and other engineers' please include engineers with a qualification of the required standard in a branch of engineering other than those referred to in items 8, 9, 10 and 11.

The object of the column headed 'Future Employment Position' is to gain a very broad picture of the total number of scientists and engineers industry aims to have in its employment in three years' time, so please give figures, even if they can only be very rough estimates. For the purpose of this return will you please make the assumption that the required number of recruits will be available.

*This part of the form relates only to the establishment to which it is addressed*

Table 1. Employment of qualified scientists and engineers

Persons with degree or listed qualifications (see definitions)	Number of persons at present mainly engaged in the following activities (please record each employee once only)			Future Employment Position		
	Research and Development	Manufacture, Production, Operation, Maintenance, Installation and Design for Manufacture	Other work	Total		
1. Agricultural scientists						
2. Biologists						
3. Chemists (excluding pharmacists)						
4. Geologists						
5. Mathematicians						
6. Metallurgists						
7. Physicists						
8. Chemical engineers						

9. Civil and structural engineers			
10. Electrical engineers			
(a) with degrees or listed qualifications			
(b) with Higher National Diplomas or Certificates only			
11. Mining engineers			
12. Mechanical and other engineers			
(a) with degrees or listed qualifications			
(b) with Higher National Diplomas or Certificates only			
			TOTAL

This means a total increase/decrease of

## RESEARCH AND DEVELOPMENT WORK

*This part of the form relates only to the establishment to which it is addressed*

6. In Table II we are asking for an estimate of the amount of staff time devoted to research and technical development at this establishment. Please include here anyone who does an appreciable amount of research or development work, even if he has been entered under some other activity in Table I, or has no degree or listed qualification.

Please enter in Table II the numbers doing any research or technical development work at this establishment at a convenient recent date. Please try to allocate the staff concerned to the categories given in the table, according to the proportions of their time they spend on this work. Where you cannot base this division on accurate figures, please make the best estimate you can without excessive effort.

The staff entered in Table II should include full-time directors and managerial staff directly responsible for this work, typists, librarians and similar ancillary staff, and operatives, male and female.

Do not include staff normally based on other establishments.

*Table II. Amount of effort devoted to scientific research and technical development*

Proportion of time devoted to research and development (percentage of working time)	Numbers of persons engaged in this work including ancillary staff			
	With degrees or listed qualifications in science or engineering		Persons without degrees, etc., in science or engineering (including H.N.C.)	Total
	Scientists	Engineers (excluding H.N.C.)		
5-24				
25-49				
50-74				
75-99				
Full-time				
Total				

1. *Establishment*

By "this establishment" we mean the factory, mill, works, department, etc. to which the attached form is addressed.

2. *Research and Technical Development*

For the purpose of this enquiry we need to draw a borderline between research and development on the one hand and production on the other hand. In the most general terms, we are trying to make this division at the point at which experimental work and the introduction of new ideas cease, further work being of a routine nature. But as, in most firms, this point is not clearly defined, the following notes on what should be included or excluded are given for your guidance. *We are not asking for the different types of research and development work to be separately distinguished in your answers to our questionnaire.*

*Please include:*

- (a) Basic and fundamental scientific research.
- (b) Applied research, technical development and technical service work, including technical design work, done so as to:
  - (i) Use different raw materials, or
  - (ii) Introduce new working methods, processes, machinery or products, or
  - (iii) Improve existing working methods, processes, machinery or products.
- (c) Prototype production.

*Please exclude:*

- (a) Routine analysis, routine inspection, routine production testing and routine quality control.
- (b) Detailed design of manufacturing units on the basis of information supplied by research.
- (c) Tooling up and similar preparation for full scale production, after the development of new plant.
- (d) Normal production for sale.
- (e) Market research.
- (f) The pre-production of aircraft.
- (g) The selling of an established product.

3. *Qualifications*

*The heading "Persons with degrees or listed qualifications" is intended to cover, in addition to university graduates, associates of certain educational institutions and graduate and associate members of certain professional bodies. For your convenience and purely as a guide for the purposes of this enquiry, a list of the qualifications to be included for this purpose is given below.*

(1) Associateship of any of the following bodies:

- (a) The Camborne School of Mines.
- (b) The City and Guilds of London Institute.
- (c) The Heriot-Watt College.
- (d) The Manchester College of Technology.
- (e) The Royal College of Science (London).
- (f) The Royal College of Science (Ireland).
- (g) The Royal School of Mines.
- (h) The Royal Technical College, Glasgow.

(2) Associate or Graduate membership of any of the following bodies:

- (a) The Royal Aeronautical Society.
- (b) The Institution of Chemical Engineers.
- (c) The Royal Institute of Chemistry.
- (d) The Institution of Civil Engineers.
- (e) The Institution of Electrical Engineers.
- (f) The Institution of Gas Engineers.
- (g) The Institute of Marine Engineers.
- (h) The Institution of Metallurgists.
- (i) The Institution of Mining and Metallurgy.
- (j) The Institution of Municipal Engineers.
- (k) The Institution of Naval Architects.
- (l) The Institute of Physics.
- (m) The Institution of Production Engineers.
- (n) The Institution of Structural Engineers.
- (o) The Institution of Mechanical Engineers.

*NOTE: H.N.D.: Items 10(b) and 12(b) of Table I should include holders of engineering diplomas of recognised technical colleges, of a standard comparable to H.N.D.*

(3) *For Table II only:*

- (a) M.R.C.S., L.R.C.P. Diploma.
- (b) Membership of the Royal College of Veterinary Surgeons.
- (c) Honours Diploma of the British Optical Association, or F.S.M.C.

## APPENDIX II

### QUESTIONNAIRES SENT OUT BY THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH TO OBTAIN FIGURES OF EXPENDITURE ON RESEARCH AND DEVELOPMENT

#### ALTERNATIVE QUESTIONNAIRE A

*Please read the covering letter before completing this form*

This questionnaire is intended to provide a convenient means of collecting information which you already keep relating to your expenditure on research and/or development work. If the questions can be varied to fit your expenditure figures better, please do so. Please leave blank any part of the form which you cannot easily answer; if, for example, you cannot conveniently separate the salaries of graduate scientists from the other salaries paid by your Research and/or Development Department, we should be glad if you would supply the total figures.

##### 1. SCOPE

(a) YEAR: The figures you give should cover an accounting year, a tax year, or a calendar year, but we would like it to be as recent as possible. Please state here the period covered: year ending

(b) NAME(S) OF COMPANY(IES): What are the names of the companies whose research and/or development expenditure is given below? (Please exclude the expenditure of associated companies outside the U.K.)

(c) INDUSTRIES: In what industries are the above companies engaged?

(d) CHOICE OF DEFINITIONS: You are asked to supply expenditure of figures for your research and/or development work EITHER as you yourself normally define it (e.g. the work done by your Research and Development Department) OR as it is defined below, whichever you find more convenient.

OPTIONAL STANDARD DEFINITION: Please include:

(a) Basic and fundamental scientific research.

(b) Applied research, technical development and technical service work, including technical design work, done so as to:

(i) Use different raw materials, or

(ii) Introduce new working methods, processes, machinery or products, or

(iii) Improve existing working methods, processes, machinery or products.

(c) Prototype production.

Please exclude:

(a) Routine analyses, routing inspection, routine production testing and routine quality control.

(b) Detailed design of manufacturing units on the basis of information supplied by research.

(c) Tooling up and similar preparation for full-scale production, after the development of new plant.

(d) Normal production for sale.

(e) Market research.

(f) The pre-production of aircraft.

(g) The selling of an established product.

PLEASE STATE HERE WHETHER YOU INTEND TO FOLLOW THE OPTIONAL STANDARD DEFINITION, by striking out the phrase which does not apply:

Our figures cover the work which we normally include in included in the standard definition of research and development.

## 2. TOTAL EXPENDITURE

What was your total expenditure on research and/or technical development work in the year given above? £.....

## 3. WAGES AND SALARIES

Please enter in Table I the wage and salary payments included in the figure for total research and development expenditure given above; also include payments to pension funds and national insurance contributions. These could be shown separately at the end of Table I if more convenient—a space is provided for this, or any other special notes.

The numbers of employed should be the yearly average of the staff and all other workers to whom the payments of wages and salaries relate.

Only wages and salaries included in the total expenditure supplied should be given here.

In some cases a Research and Development Department makes payments to another department of the same firm, which does work, and so pays wages, on its behalf. Such payments of wages should not be included in Table I.

Please count as fractions people who devoted only part of their time to this work.

Table I. *Wages and salaries*

	Persons with degrees or equivalent qualifications in science or engineering (please see definitions below)	Persons without degrees, etc., in science or engineering	Total
Numbers			
Wages and salaries attributed to this work (£)			

## DEFINITION OF QUALIFICATIONS

The heading "Persons with degrees or equivalent qualifications" is intended to cover, in addition to university graduates, the following:—

(1) Associates of any of the following bodies:

- (a) The Camborne School of Mines.
- (b) The City and Guilds of London Institute.
- (c) The Heriot-Watt College.
- (d) The Manchester College of Technology.
- (e) The Royal College of Science (London).
- (f) The Royal College of Science (Ireland).
- (g) The Royal School of Mines.
- (h) The Royal Technical College, Glasgow.

(2) Associates or Graduate members of any of the following bodies:

- (a) The Royal Aeronautical Society.
- (b) The Institution of Chemical Engineers.
- (c) The Royal Institute of Chemistry.
- (d) The Institution of Civil Engineers.
- (e) The Institution of Electrical Engineers.
- (f) The Institution of Gas Engineers.
- (g) The Institute of Marine Engineers.
- (h) The Institution of Mechanical Engineers.
- (i) The Institute of Metallurgists.
- (j) The Institution of Mining and Metallurgy.
- (k) The Institution of Municipal Engineers.
- (l) The Institution of Naval Architects.
- (m) The Institute of Physics.
- (n) The Institution of Production Engineers.
- (o) The Institution of Structural Engineers.

(3) M.R.C.S., L.R.C.P.

(4) Members of the Royal College of Veterinary Surgeons.

(5) Honours Diploma of the British Optical Association, or F.S.M.C.

#### 4. OTHER COSTS (materials, overheads, etc.)

- (a) If you keep figures of costs, other than the wages and salaries already given, incurred in connection with your research and/or development work, what was the total sum? £.....
- (b) Does your research (and/or development) department have any receipts from sales of products? (This should not include payments for research or development works as such) YES/NO  
If so:
  - (i) Have they been deducted from your figures of expenditure given above? YES/NO
  - (ii) How much did you receive from this source? £.....
  - (iii) How much in wages and salaries can be charged to this production? £.....
- (c) A list is given below of some of the items which may have been included in the total already given. This is included firstly to obtain information on which of these items has been included in your total expenditure figure, and secondly to provide a space in which any detailed expenditure figures which you can conveniently provide can be put down. Please cross out any item (or part of an item) which was not included in the total given above, and if you can also, with ease, state the actual amount spent on any item, or group of items, please do so. A space is provided for you to write in any additional items not covered by the list, or any more convenient grouping of items. Where you cannot easily give a figure, please leave the space blank.

Table II. *Check list of other costs of research and for development work*

Please see instructions in para. (c) above.

Please strike out any item which is <i>not</i> included in the total given under 4 (a) above	If you can conveniently state the amount spent on any of these items, please do so here
DEPRECIATION	
Buildings	
Equipment	
Furniture	
MAINTENANCE AND REPAIRS	
Buildings	
Equipment	
Furniture	
PURCHASES (on revenue account)	
Materials	
Equipment	
Furniture	
BOOKS AND JOURNALS	
Books	
Journals	
WORKS SERVICES	
Electricity	
Gas	
Steam	
Cleaning	
Other Works services	
RENT	
Building not owned by you	
Allowance for rent on your own buildings	

Please strike out any item which is not included in the total given under 4 (a) above	If you can conveniently state the amount spent on any of these items, please do so here
OFFICE EXPENSES, ETC.	
Stationery and printing	
Clerical assistance (if not entered in Table I)	
Postage and telephones	
PAYMENTS FOR RESEARCH AND DEVELOPMENT WORK DONE BY OTHER BODIES	
Government departments and laboratories (excluding statutory levies)	
Co-operative Industrial Research Associations (including annual membership fee, if paid direct)	
Universities, technical colleges, and other learned institutions	
MISCELLANEOUS EXPENSES	
Travelling expenses	
Entertainment	
Canteen, welfare, etc.	
Patent fees and legal expenses	
ANY OTHER ITEMS ? Please specify below	

## 5. TYPES OF RESEARCH AND DEVELOPMENT WORK DONE

If you have not used the optional standard definition, please mark with a tick in the left hand column of Table III each type of work normally included in the research and/or development work for which you have given expenditure figures. If ANY OF THE TYPES OF WORK LISTED IN TABLE III IS CARRIED OUT BY YOUR FIRM BUT WOULD NOT NORMALLY BE INCLUDED IN THE FIGURES FOR RESEARCH AND DEVELOPMENT, PLEASE DO NOT TICK IT.

Table III. *Check list of types of research and development work*

1. Basic and fundamental scientific research
2. Laboratory or small scale investigation of possible new materials and purchased components
3. Trying out new raw materials and purchased components in the factory or works
4. Establishing specifications for raw materials and purchased components
5. Routine testing of raw materials and purchased components
6. Research on methods of testing raw materials and purchased components
7. Designing modifications to existing machinery for your own use
8. Design and development of new machinery for your own use
9. Construction of prototypes of new machinery for your own use
10. Trying out new machinery in the factory or works
11. Small scale investigation of new methods of production
12. Testing new methods of production in operation
13. Production control
14. Testing for control purposes
15. Laboratory or small scale investigation of new processes
16. Testing new processes in operation
17. Routine testing of products
18. Research on methods of testing products
19. Design of new products
20. Development of prototypes of new products
21. Production of prototypes
22. Testing prototypes
23. Development of components
24. Running pilot plant
25. Work study
26. Methods engineering
27. Operational research

Table III (*continued*)

	28. Research on industrial health and safety
	29. Technical services to customers
	30. Technical sales
	31. Market or sales research
	32. Investigation of customers' complaints
	33. Training of personnel
	34. Statistical services to production departments
	35. Library services
	36. Other technical services to manufacturing departments
	37. Any other type of research or development (please specify)

## ALTERNATIVE QUESTIONNAIRE B

*Please read the covering letter before completing this form*

This form is intended for firms who can supply no figures apart from their total expenditure on research and/or technical development work, the wages and salaries paid, and the numbers of personnel working on research and/or technical development work.

1. What was your total expenditure on research and/or technical development work in the most recent year for which you have figures?

£
---

2. On what date did that year end? .....

3. How many persons were engaged in this work? Please count people who devoted only part of their time to this work as fractions. If possible, please distinguish between graduates and others (see definitions).

	Graduates in science or engineering	Others	Total
Number of persons	.		

4. How much of the expenditure given above was for wages, salaries, insurance and pension contributions?

£
---

5. (a) What are the names of the companies whose research and development expenditure is given above?

- (b) What main industries are they engaged in?

6. It would help us greatly in the interpretation of the figures you have given above if you would tick those items in the following two check-lists which are covered by your figures of expenditure.

**CHECK LIST OF OTHER COSTS OF RESEARCH AND DEVELOPMENT WORK**

Please mark with a tick each item of possible expenditure which has been included in the total expenditure figure given above

	<b>DEPRECIATION</b>
	Buildings
	Equipment
	Furniture
	<b>MAINTENANCE AND REPAIRS</b>
	Buildings
	Equipment
	Furniture
	<b>PURCHASES (on revenue account)</b>
	Materials
	Equipment
	Furniture
	<b>BOOKS AND JOURNALS</b>
	Books
	Journals
	<b>WORKS SERVICES</b>
	Electricity
	Gas
	Steam
	Cleaning
	Other works services
	<b>RENT</b>
	Building not owned by you
	Allowance for rent on your own buildings

CHECK LIST OF OTHER COSTS OF RESEARCH AND DEVELOPMENT WORK  
(contd.)

Please mark with a tick each item of possible expenditure which has been included in the total expenditure figure already given

	OFFICE EXPENSES, ETC.
	Stationery and printing
	Clerical assistance (if not entered in Table I)
	Postage and telephones
	PAYMENTS FOR RESEARCH AND DEVELOPMENT WORK DONE BY OTHER BODIES
	Government departments and laboratories (excluding statutory levies)
	Co-operative Industrial Research Associations (including annual membership fee, if paid direct)
	Universities, technical colleges, and other learned institutions
	MISCELLANEOUS EXPENSES
	Travelling expenses
	Entertainment
	Canteen, welfare, etc.
	Patent fees and legal expenses
	ANY OTHER ITEMS ?
	Please specify below

## 7. TYPE OF RESEARCH AND DEVELOPMENT WORK DONE

Please mark with a tick in the left hand column of the following table each type of work normally included in the research and development for which you have supplied expenditure figures. IF ANY OF THE TYPES OF WORK LISTED IS CARRIED OUT BY YOUR FIRM BUT WOULD NOT NORMALLY BE INCLUDED IN THE FIGURES FOR RESEARCH AND DEVELOPMENT GIVEN ABOVE, PLEASE DO NOT TICK IT.

### CHECK LISTS OF TYPES OF RESEARCH AND DEVELOPMENT WORK

	1. Basic and fundamental scientific research
	2. Laboratory or small scale investigation of possible new materials and purchased components
	3. Trying out new raw materials and purchased components in the factory or works
	4. Establishing specifications for raw materials and purchased components
	5. Routine testing of raw materials and purchased components
	6. Research on methods of testing raw materials and purchased components
	7. Designing modifications to existing machinery for your own use
	8. Design and development of new machinery for your own use
	9. Construction of prototypes of new machinery for your own use
	10. Trying out new machinery in the factory or works
	11. Small scale investigation of new methods of production
	12. Testing new methods of production in operation
	13. Production control
	14. Testing for control purposes
	15. Laboratory or small scale investigation of new processes
	16. Testing new processes in operation
	17. Routine testing of products
	18. Research on methods of testing products
	19. Design of new products
	20. Development of prototypes of new products
	21. Production of prototypes
	22. Testing prototypes
	23. Development of components

CHECK LISTS OF TYPES OF RESEARCH AND DEVELOPMENT WORK—*contd.*

24. Running pilot plant
25. Work study
26. Methods engineering
27. Operational research
28. Research on industrial health and safety
29. Technical services to customers
30. Technical sales
31. Market or sales research
32. Investigation of customers' complaints
33. Training of personnel
34. Statistical services to production departments
35. Library services
36. Other technical services to manufacturing departments
37. Any other type of research or development (please specify)